Process Control and Enhancement

by

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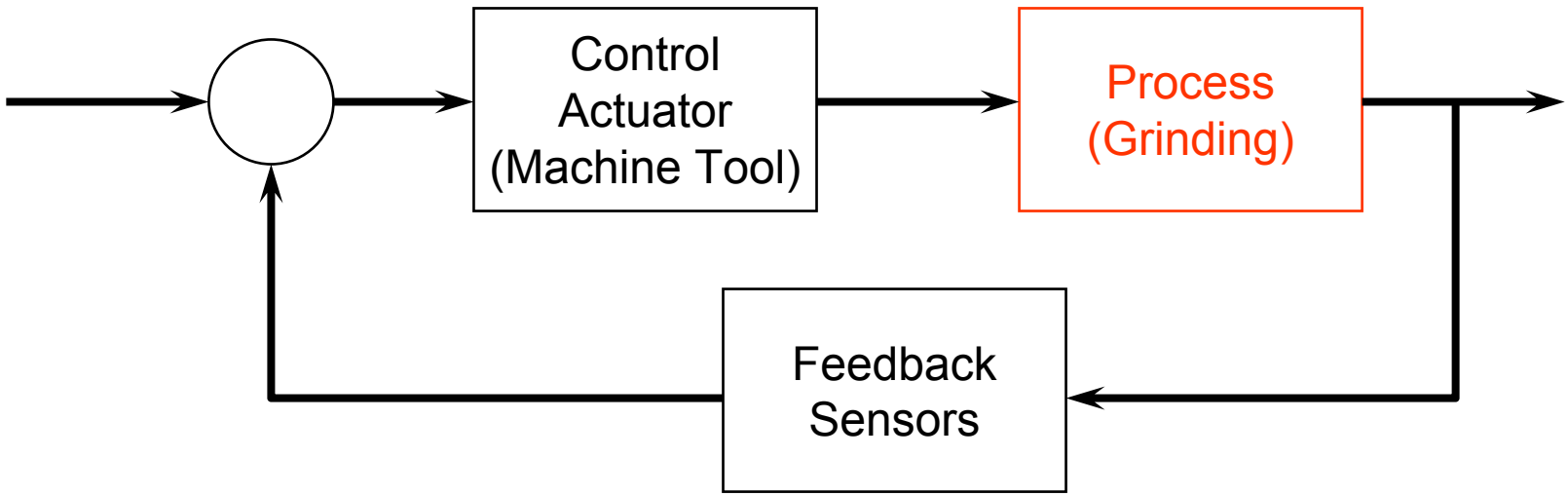
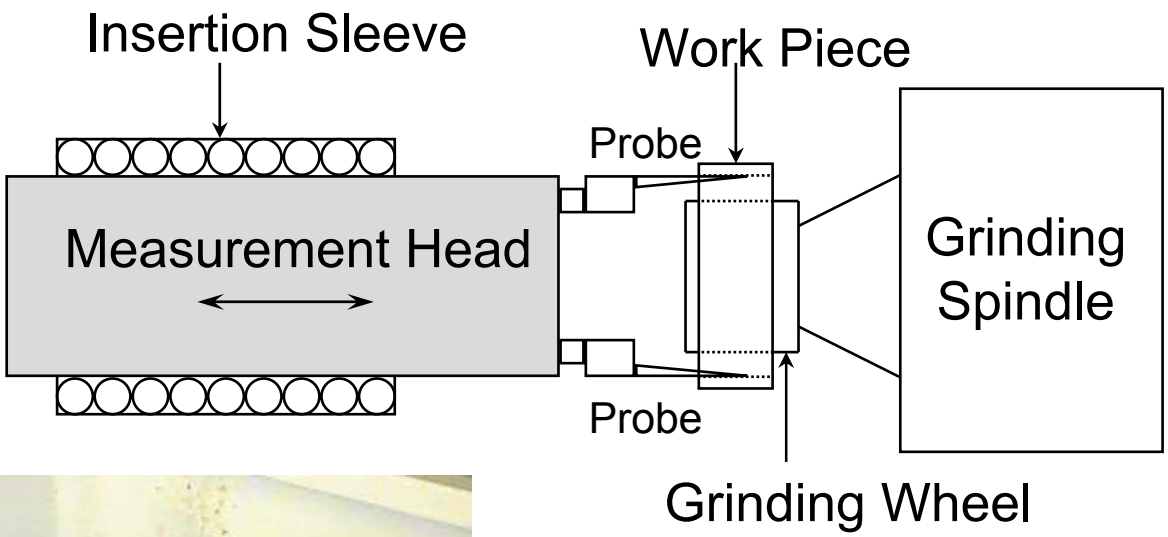
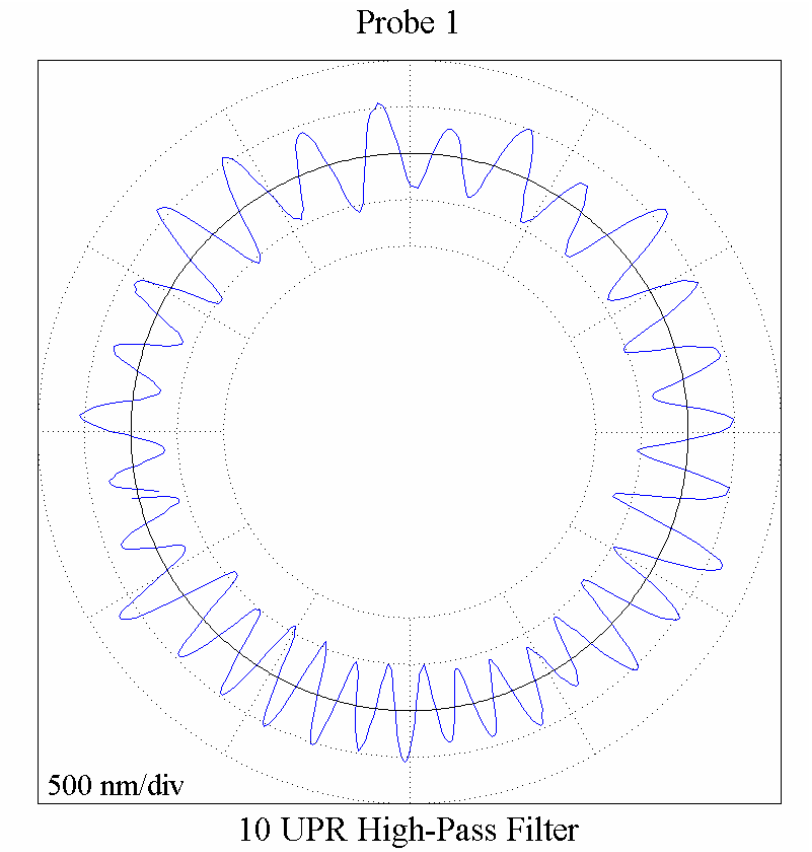
Manufacturing Process

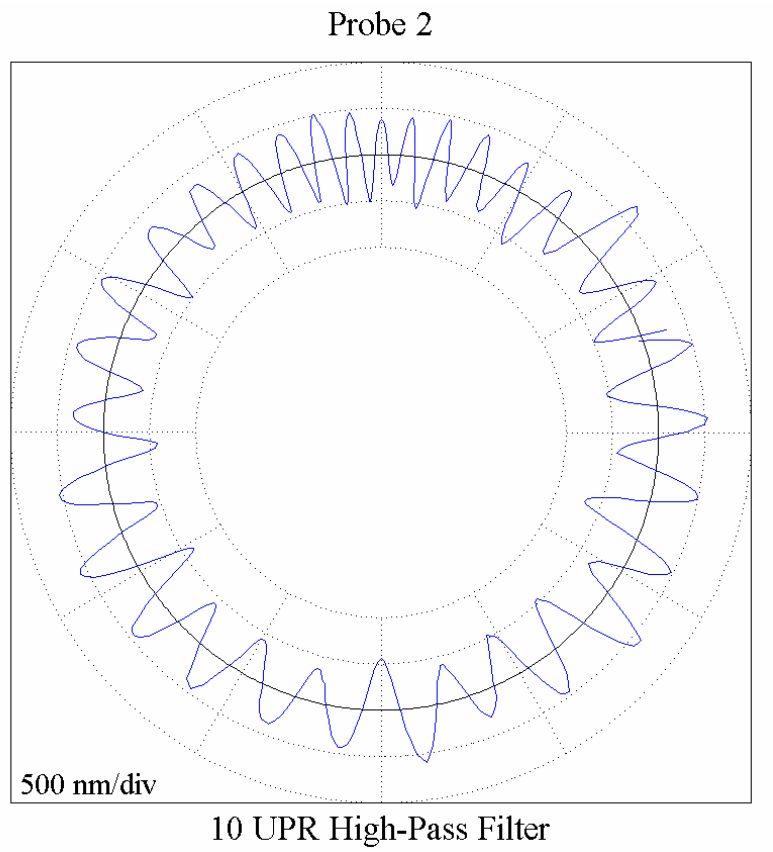


An Old Sensor a New Use



Real-Time Measurement



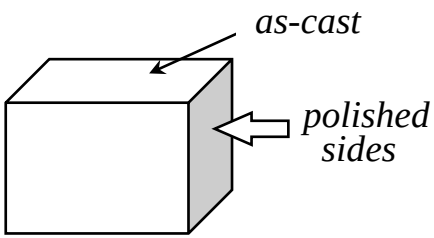


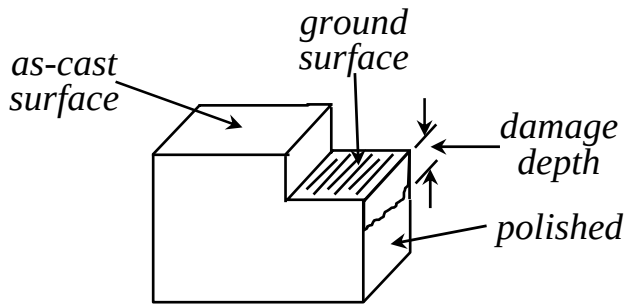
Redefining the Rules

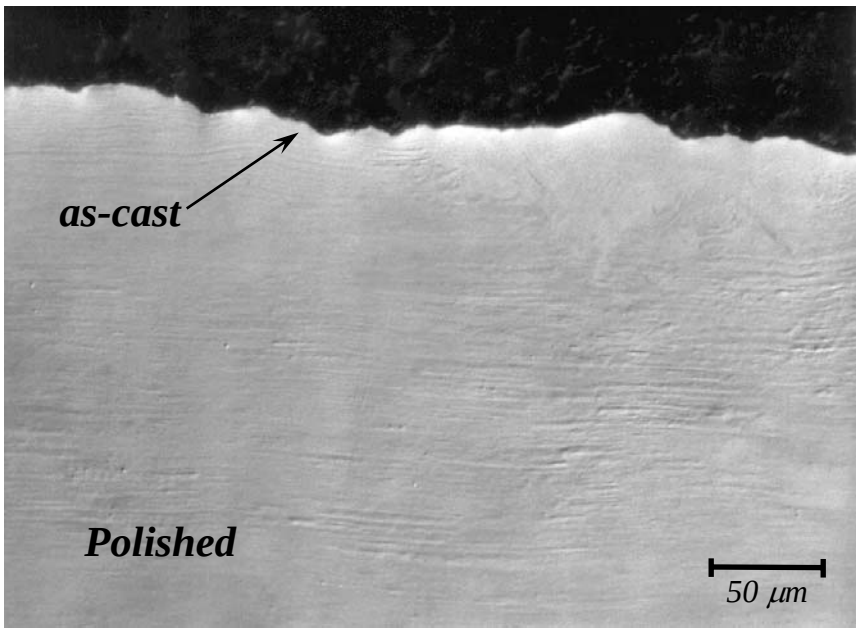
Georgia Tech

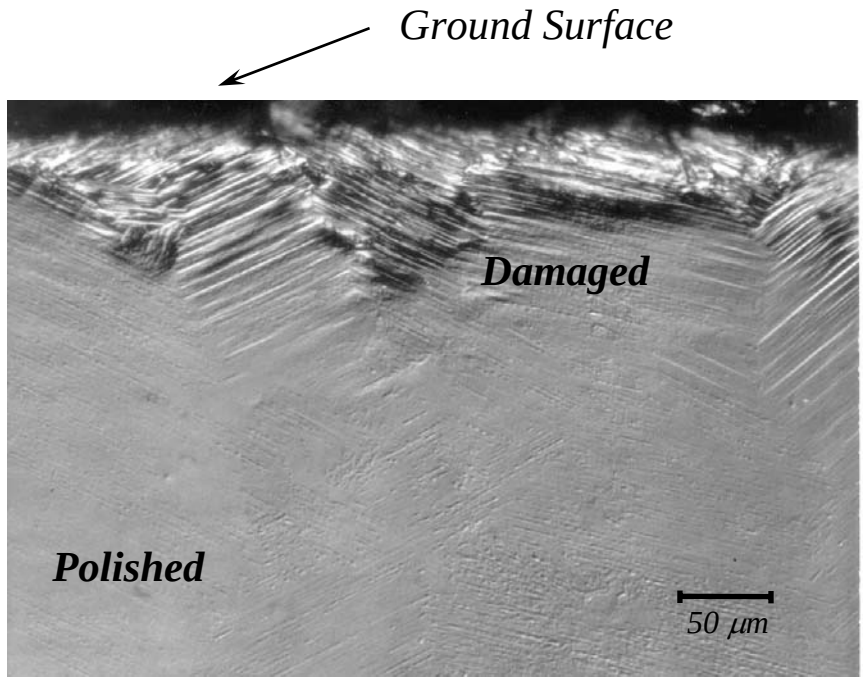
- Open Architecture
  - Machine tools
  - Measurement systems
- Enhanced Metrology
  - 3-Dimensional
  - Real-Time interface
- Example: Turbine Blade Production
  - Process modeling
  - Process control
  - Metrology.

Subsurface Damage



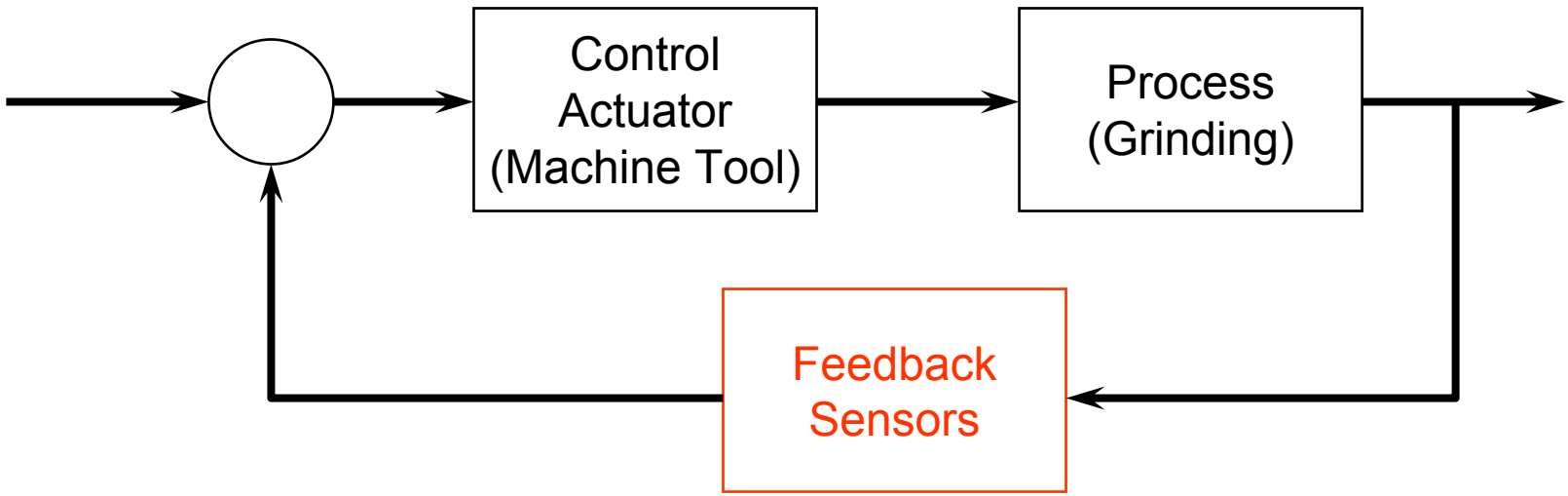






V_s=30 m/s, V_w=0.5 m/min, a=25 μm

Manufacturing Process

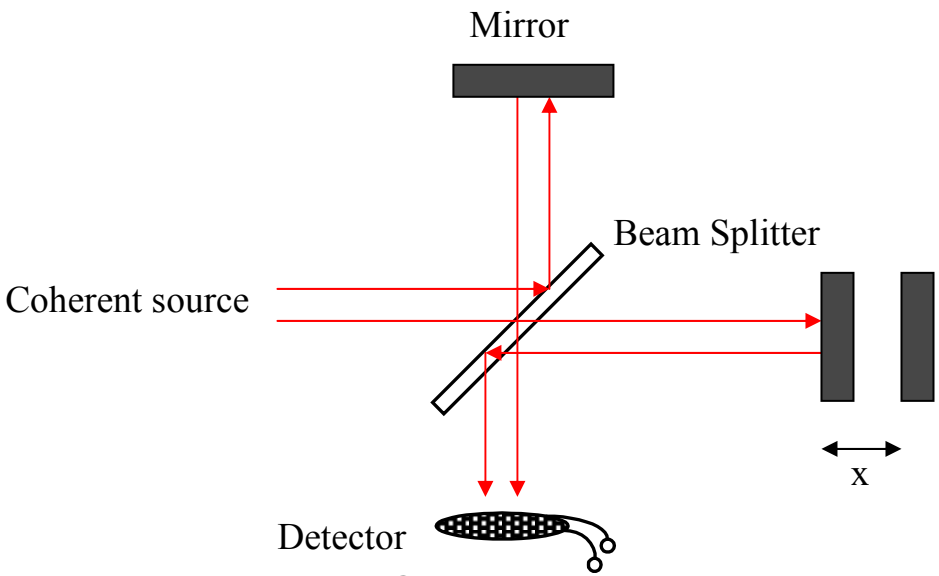


Small Sensors Satisfying Big Needs

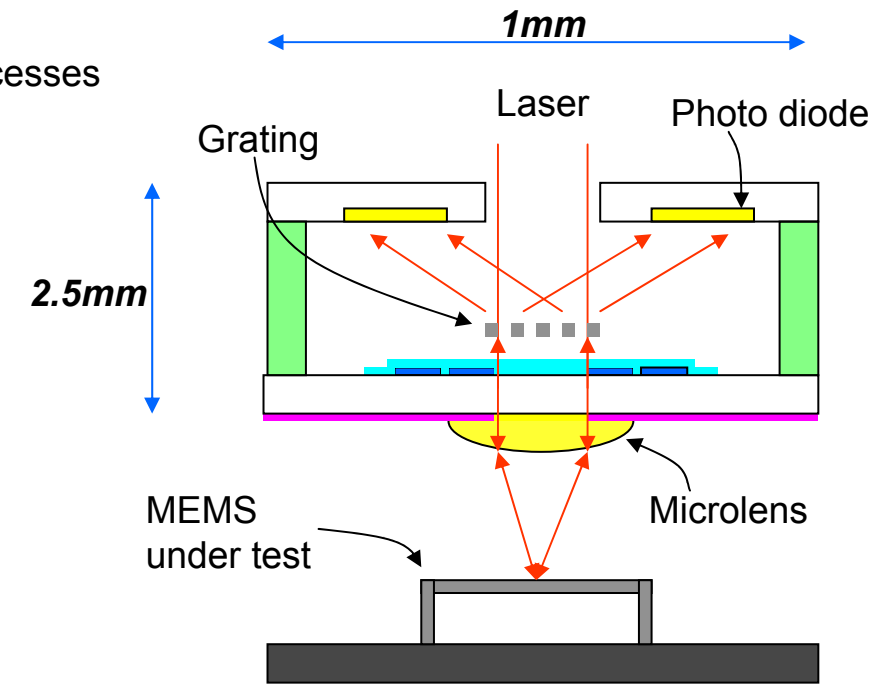
- High precision
- Fast
- Ability to analyze multiple devices
- Robust
- In-line and in-process
- Low cost
- Intelligent

New Compact Design - μSGI

- Compact design: eliminating beam splitter, integration of electronics
  - Bulky → small (1x1x2.5 mm^3)
- Using a grating interferometer (Manalis *et al*, 1996)
  - Based on intensity measurement of the diffraction pattern
  - Displacement equivalent noise:10^{-5} Å/√Hz → resolution
- Better resolution at focus by microlens
- Expensive → Competitive
  - proven microelectronics manufacturing processes

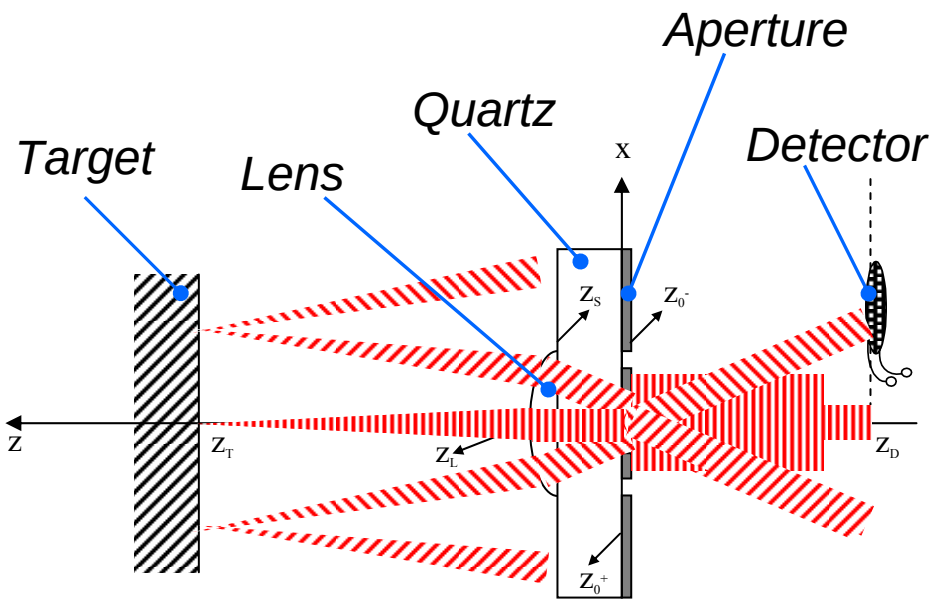


Conventional design



Compact design

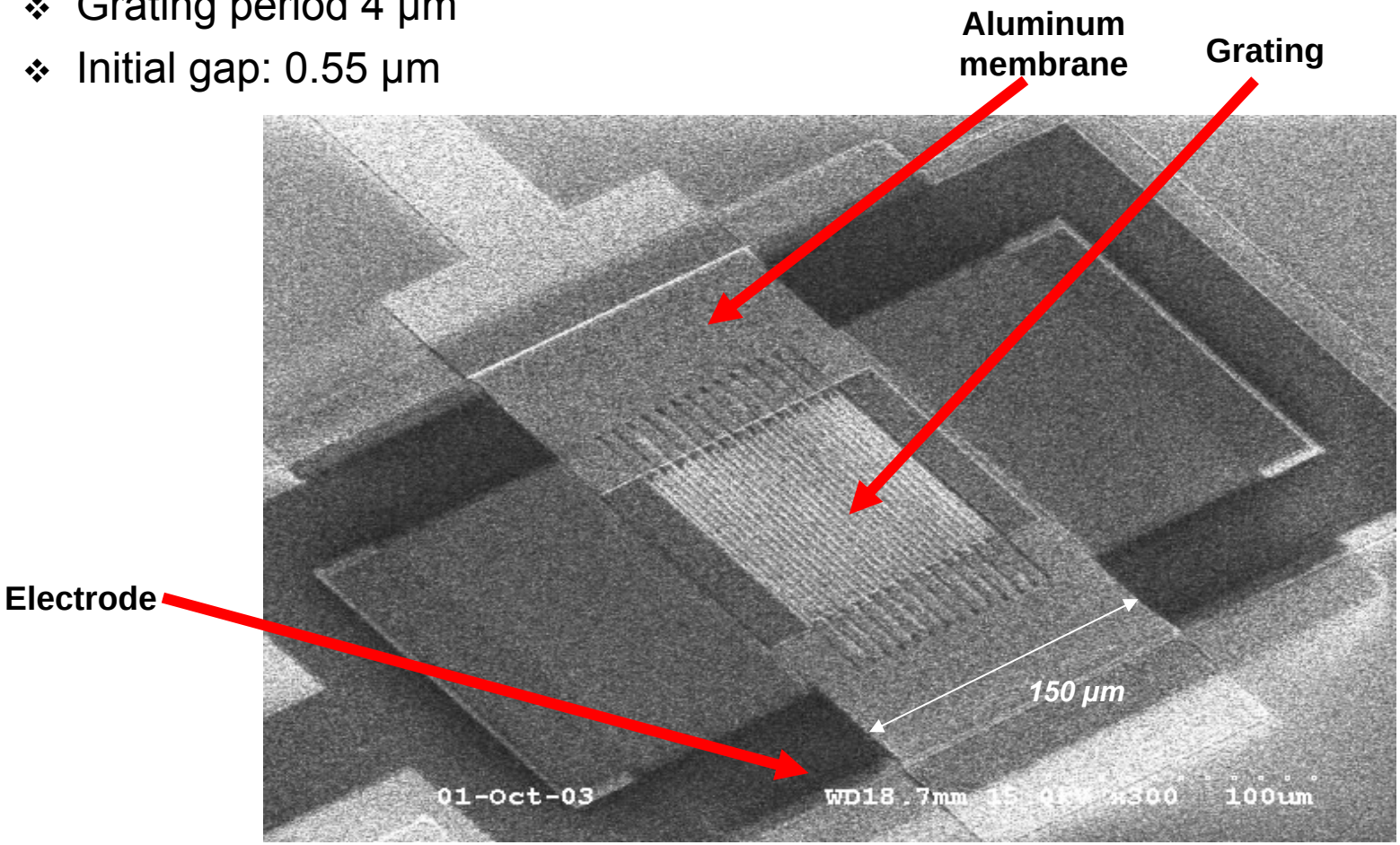
Detailed Beam Path



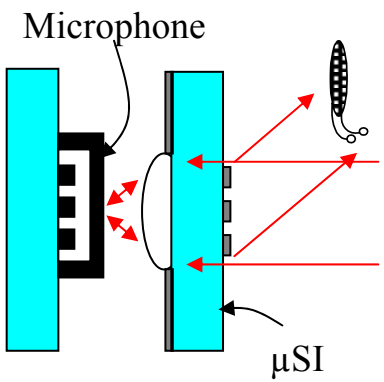
Coordinate system of analysis

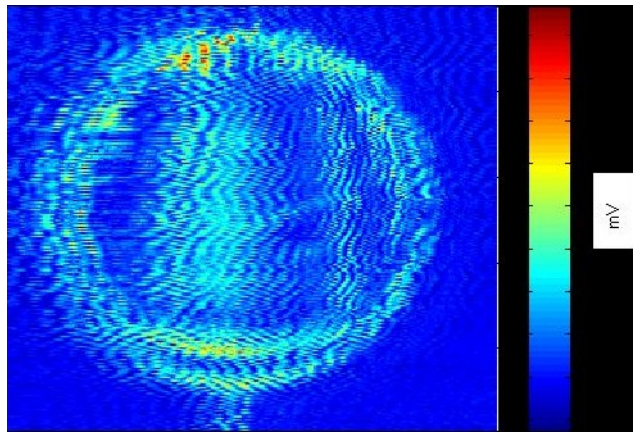
SEM of Fabricated Micro-Interferometer

- Aluminum layer thickness: 1.8 μm and 0.6 μm
- Grating period 4 μm
- Initial gap: 0.55 μm

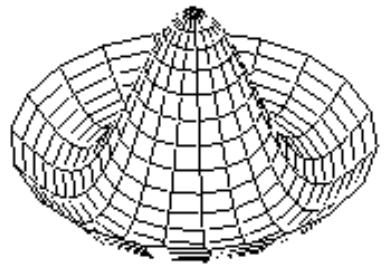


Improved Imaging Results-2nd Mode

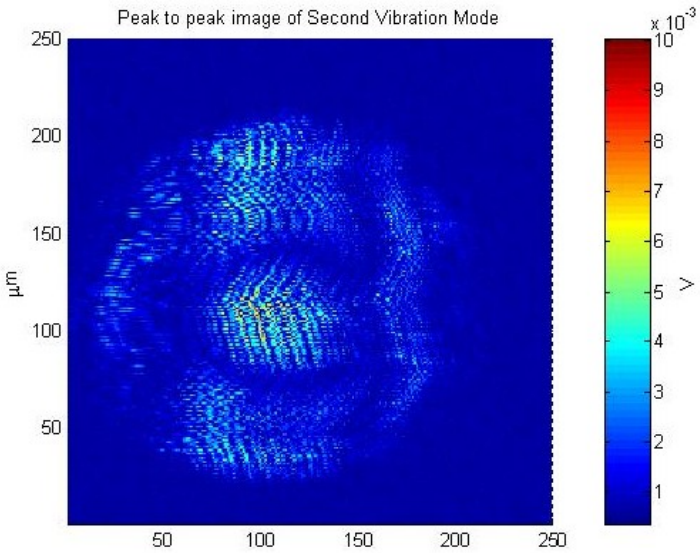




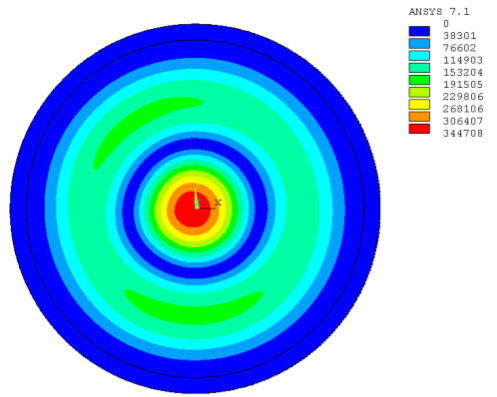
DC



- *Φ190μm microphone*
- *2nd mode at 1.25MHz, DC 40V, AC 10V*
- *Vibration noise and fringes due to tilt & membrane curvature*

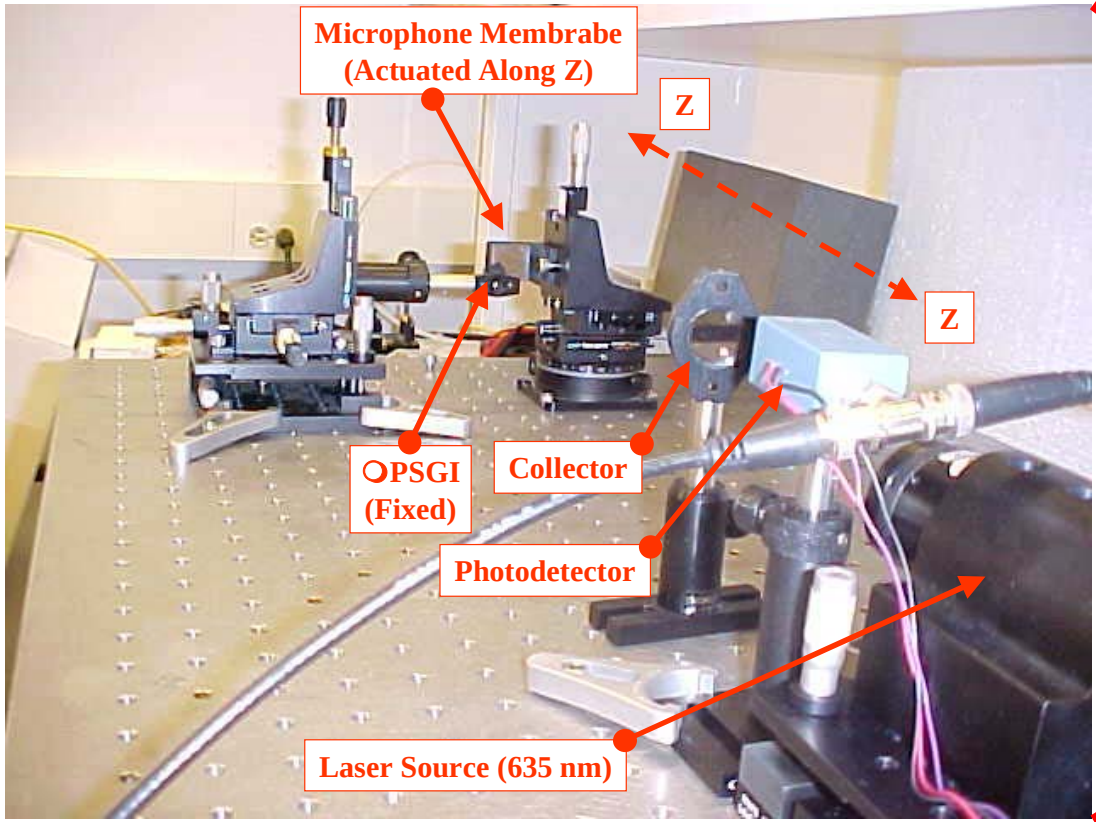


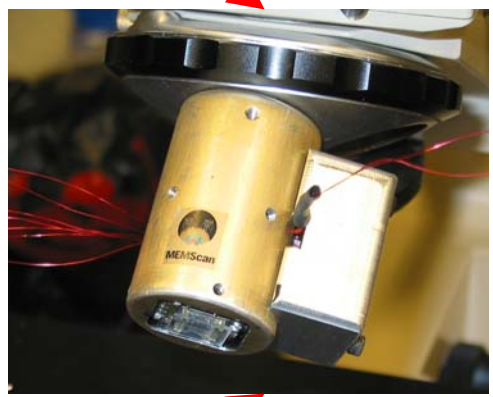
Motion at 2nd mode, AC



2nd mode in FEM

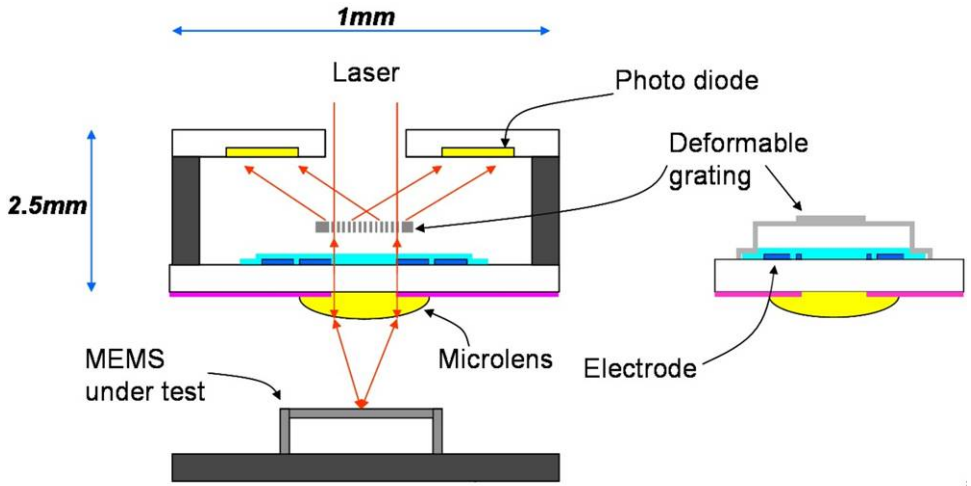
We Have Come Far!!!



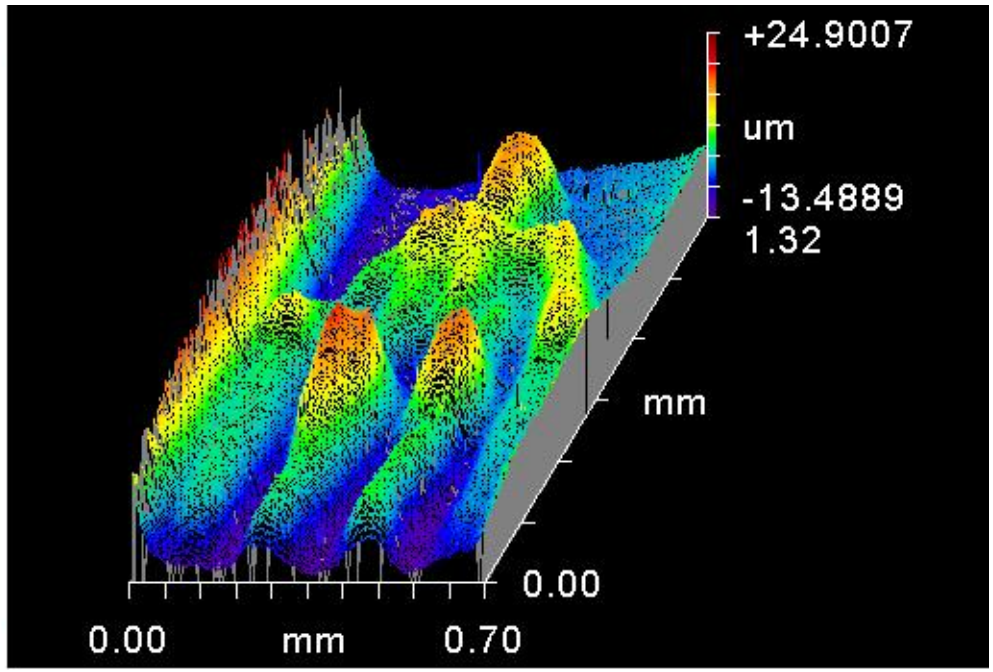


Technology Summary

- Emerging technology from Georgia Tech
- Based off of traditional laser interferometry, but on the micro scale
- Size 1mm x 1mm x 2.5mm
- Manufactured by standard silicon processing techniques
- Resolution:
  - Vertical: 0.5 nm
  - Lateral: 3.5 μm
- Potential to be produced in an array for fast inspection of entire wafers

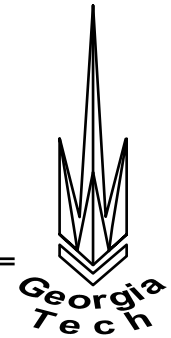


Thinking Small Micro-Metrology - A Penny.



Another Direction - Thinking Big

Educational Issues



- Excellent Fundamental Problems
  - Undergraduate
  - Graduate
- Interdisciplinary
- Practical in Nature
- Real World Examples
- Basis for Professional Training

Conclusions

- Process Control is Viable
  - Classical parameters
  - New parameters
- Utility of Open Architecture Machines
- Real-Time adaptive control
  - Process parameter estimation
  - Integration of new sensors
- Next Generation Metrology
  - Real-Time
  - 3 D
  - Large Scale
  - Small Scale
- *We Can Do It All!*
  - Fundamental work
  - Industrial application
  - Education